PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
F28C 3/14 // B01J 8/12, B04C 5/081, F26B 3/16, C04B 7/43

A1

(11) International Publication Number: WO 98/04879

(43) International Publication Date: 5 February 1998 (05.02.98)

(21) International Application Number: PCT/EP97/03512

(22) International Filing Date: 3 July 1997 (03.07.97)

(30) Priority Data:
0820/96 30 July 1996 (30.07.96) DK

(71) Applicant (*for all designated States except US*): F.L. SMIDTH & CO. A/S [DK/DK]; Vigerslev Alle 77, DK-2500 Valby (DK).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): FONS, Mogens, Juhl [DK/DK]; Vigerslev Alle 77, DK-2500 Valby (DK).

(74) Agent: GILL JENNINGS & EVERY; Broadgate House, 7 Eldon Street, London EC2M 7LH (GB).

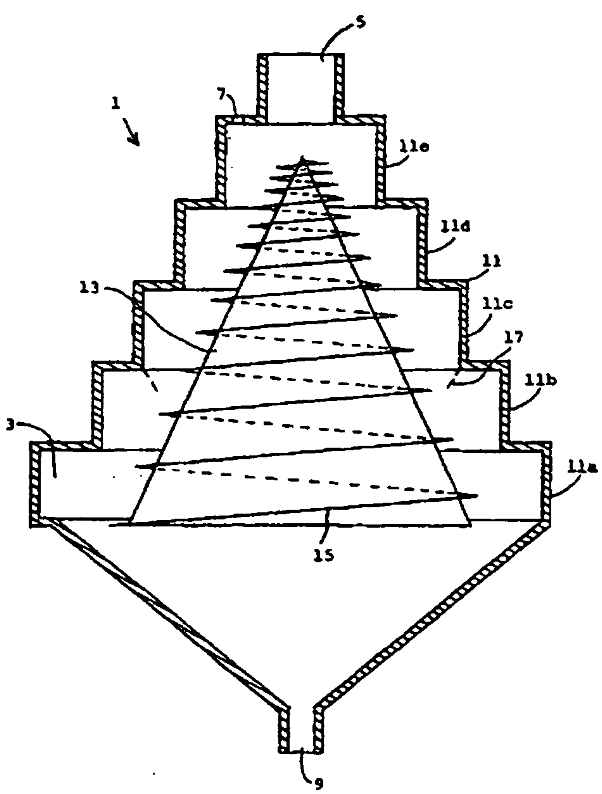
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: APPARATUS FOR EFFECTING HEAT EXCHANGE BETWEEN A GAS AND A FINE PARTICULATE MATERIAL

(57) Abstract

A device (1) for exchange of heat between a gas and a fine-grained material, such as cement raw meal, comprising a vertical, rotationally symmetrical shaft (11) which is provided with gas inlets (3) at its lower end, a central gas outlet (5) at its upper end, a material inlet (7) likewise at its upper end, and a central material outlet (9) at its lower end. The gas passes through the shaft from the lower end and upwards following a helical path, whereas the material fed at the top and discharged at the bottom during its passage through the shaft is repeatedly thrust outwards against the wall of the shaft and re-introduced into the gas stream. The shaft is made up of several cylindrical shaft sections (11a, 11b, 11c, 11d, 11e), positioned on top of one another, the diameters of which decrease from the lower end upwards, and the gas inlets (3) are configured tangentially in the lowermost shaft section (11a).



APPARATUS FOR EFFECTING HEAT EXCHANGE BETWEEN A GAS AND A FINE PARTICULATE MATERIAL

The present invention relates to a device for achieving exchange of heat between a gas and a fine-grained material, such as cement raw meal, the device comprising a substantially vertical, rotationally symmetrical shaft which is provided with at least one gas inlet at its lower end, a central gas outlet at its upper end, and a material inlet likewise at its upper end, and a central material outlet at its lower end, through which shaft the gas stream passes through from the lower end and upwards along a helical path, whereas the material which is fed at the top and discharged at the bottom during its passage through the shaft is repeatedly thrust outwards against the wall of the shaft and re-introduced into the gas stream.

The invention relates particularly to a heat exchange device in which an exchange of heat is achievable between hot gas and cold fine-grained material according to the counterflow principle and in such a way that the hot gas when passing up through the device is cooled down from a high inlet temperature, which typically ranges between 1000 and 1200°C, to a low discharge temperature within the range 100 - 200°C above the ambient temperature, while, simultaneously, during its passage down through the device the material is heated from a low inlet temperature, typically corresponding to the ambient temperature, to a high discharge temperature within the range 0 - 200°C below the inlet temperature of the gas.

Devices of the aformentioned kind are known from, e.g., DE-B-1178001 and DE-B-1813519.

DE-B-1178001 discloses a heat exchange device comprising a cylindrical shaft which is made up of several sections positioned on top of one another, and in which the material is introduced at the top and discharged at the bottom, whereas the gas is introduced axially at the bottom and discharged axially at the top. In order to ensure that the gas is flowing up through the shaft along a helical path, thereby achieving a cyclone-like effect causing the material to be forced out towards the wall of the shaft and

causing it to drop into the underlying shaft section, the said patent specification suggests that a sub-stream of the discharge gas is separated from the principal gas stream and subsequently injected at high velocity tangentially into the shaft. Optimum efficiency cannot be achieved with such a device since it uses the relatively low-temperature discharge gas as injection gas, thereby lowering the temperature in the lower part of the shaft.

DE-B-1813519 describes another heat exchange device which comprises a cylindrical shaft of identical diameter over its entire length. The gas is introduced tangentially at the bottom of the shaft and, as a consequence hereof, follows a helical path up through the shaft. The shaft comprises a number of outwardly buckling features which function as guiding faces for re-introducing the material into the gas stream. In order to ensure optimum efficiency of this device, the gas stream must be capable of imparting to the material a relatively high tangential velocity, so that the material leaves the outwardly buckling features at a high radial velocity and does not just fall down along the shaft wall. In cases where heat exchange of the kind described above is desirable, the temperature of the gas will decrease substantially up through the shaft. Due to the fact that this will substantially increase the bulk density of the gas, the velocity of the gas will also decrease which means that the tangential velocity component in the upper part of the shaft will not be sufficient to impart to the material the intended radial velocity at the outwardly buckled features. Therefore, the heat exchange between the gas and the material will be restricted in the upper part of the shaft.

A further disadvantage of both of the known devices is the fact that their separation efficiency appears to be insufficient, and, therefore, it will be necessary to install a separation cyclone immediately above the device. This will increase the overall height of the device.

It is an object of the present invention to provide a heat exchange device by means of which the aforementioned drawbacks are remedied.

According to the invention this is achieved by a device of the kind mentioned in the introduction and characterized in that the shaft is built up of several substantially cylindrical shaft sections positioned on top of one another, with the diameter of the sections decreasing from the bottom upwards, and in that the gas inlet(s) is (are) provided tangentially in the lowermost shaft section.

Hence a compact heat exchange device is provided, which will ensure efficient heat exchange between the gas and the material as well as a material separation efficiency which is high enough to eliminate the need for a subsequent separation cyclone. This is due to the fact that the tangentially fed gas maintains, all the way up through the shaft, a sufficiently high tangential velocity for the material in each shaft section to be thrust out towards the shaft wall and thereby separated from the gas, and the fact that on its passage down through the shaft the material is repeatedly directed back into the gas stream. The very fact that the shaft is made up of a number of shaft sections positioned on top of one another, with the diameter, and hence the cross-sectional area, of the shaft sections decreasing from the bottom upwards, means that the shaft volume available for gas stream passage will drop proportionately to the volume of the gas. Hence the circumferential velocity of the gas can be maintained all the way up through the shaft through appropriate selection of the shaft dimensions relatively to the temperature drop of the gas.

In order further to ensure that the gas velocity can be maintained all the way up through the shaft, it may in some cases be desirable to fit the shaft internally with a filler body. The filler body may advantageously take the

form of a cone or a truncated cone which is placed coaxially with the shaft.

Furthermore, the filler body may be equipped on its outer side with guiding means, particularly in the form of plates, which are fitted horizontally or at a moderately inclining angle viewed in relation to the tangential velocity component of the gas so that the gas will follow a helical path at a very small rate of inclination and with the maximum achievable circumferential velocity. The guiding means may advantageously consist of a helicoid guide plate with an angle of inclination of approximately 5°.

The lower part of each shaft section may be configured as an inverted truncated cone so as to ensure that the material which drops from one shaft section to the next one is retained in the gas stream during an extended period of time, thereby increasing the temperature of the material. A slight protrusion of the lower part of each shaft section into the underlying shaft section may also be advantageous.

In a particular embodiment of the invention it is preferred that the relationship between the diameter and height of each shaft section is between 2 and 10, preferably between 3 and 6.

It is further preferred that the relationship between the diameters of two adjacent shaft sections is between 8:7 and 3:2, preferably between 6:5 and 4:3.

The invention will now be described in further detail with reference to the accompanying diagrammatical drawing, which shows a heat exchange device according to the invention viewed in axial section.

The figure depicts a heat exchange device 1 which comprises a vertical, rotationally symmetrical shaft 11 which is formed with a tangential gas inlet 3 at its lower end, a central gas outlet 5 at its upper end, a material inlet 7 also at its upper end, and a central material outlet 9 at its lower end.

According to the invention the shaft 11 is divided into a number of cylindrical shaft sections 11a, 11b, 11c, 11d, 11e, the diameters D of which decrease from the bottom and upwards. The tangential gas inlet 3 is configured in the lowermost shaft section 11a.

The illustrated heat exchange device further comprises a filler body in the form of a cone 13 which is fixed coaxially within the shaft 11 in unspecified manner. On its outer side the cone 13 is provided with a helicoid guide plate 15 with an angle of inclination of 5°. The primary function of the guide plate 15 is to force the gas stream into following a helical path up through the shaft 11 at the smallest possible angle of inclination so that the gas achieves the maximum attainable circumferential velocity. The guide plate 15 has a width which is preferably such that it protrudes between one-fifth and one-third of the way into the shaft space between the shaft wall and the cone.

As indicated by means of dotted lines at shaft section 11c, the lower part of each shaft section may be configured as an inverted truncated cone 17 which protrudes slightly into the underlying shaft section.

During operation of the heat exchange device according to the invention a uniform flow of material is directed into the uppermost shaft section 11e via the opening 7. Here the material is entrained in the gas stream which is circulating at a high velocity and after being retained in the gas stream for a certain period of time during which the material is heated to a temperature close to that of the gas, the material is thrust out towards guide face formed by the wall of the shaft section, wherefrom it drops down into the underlying shaft section 11d in which the process is repeated.

Hence the material is gradually heated as it is flows down through the shaft while, at the same time, the gas is cooled accordingly as it flows up through the shaft. The heated material is discharged from the shaft via the outlet

9 whereas the cooled gas stream is discharged via the outlet 5.

CLAIMS

1. A device (1) for achieving exchange of heat between a gas and a fine-grained material, such as cement raw meal, the device comprising a substantially vertical, rotationally symmetrical shaft (11) which is provided with at least one gas inlet (3) at its lower end, a central gas cutlet (5) at its upper end, a material inlet (7) likewise at its upper end, and a central material outlet (9) at its lower end, and through which shaft the gas stream passes, in use, through from the lower end and upwards along a helical path, whereas the material which is, in use, fed at the top and discharged at the bottom during its passage through the shaft is repeatedly thrust out against the wall of the shaft and re-introduced into the gas stream; **characterized in that** the shaft is made up of several substantially cylindrical shaft sections (11a, 11b, 11c, 11d, 11e) positioned on top of one another, with the diameter of the sections decreasing from the bottom upwards, and in that the gas inlet(s) (3) is (are) configured tangentially in the lowermost shaft section (11a).

2. A device according to claim 1, **characterized in that** the shaft is fitted internally with a filler body (13).

3. A device according to claim 2, **characterized in that** the filler body (13) is configured as a cone or a truncated cone which is placed coaxially with the shaft.

4. A device according to claim 3, **characterized in that** the filler body (13) is equipped on its outer side with guiding means (15), particularly in the form of plates, which are fitted horizontally or at a moderately inclining angle viewed in relation to the tangential velocity component of the gas.

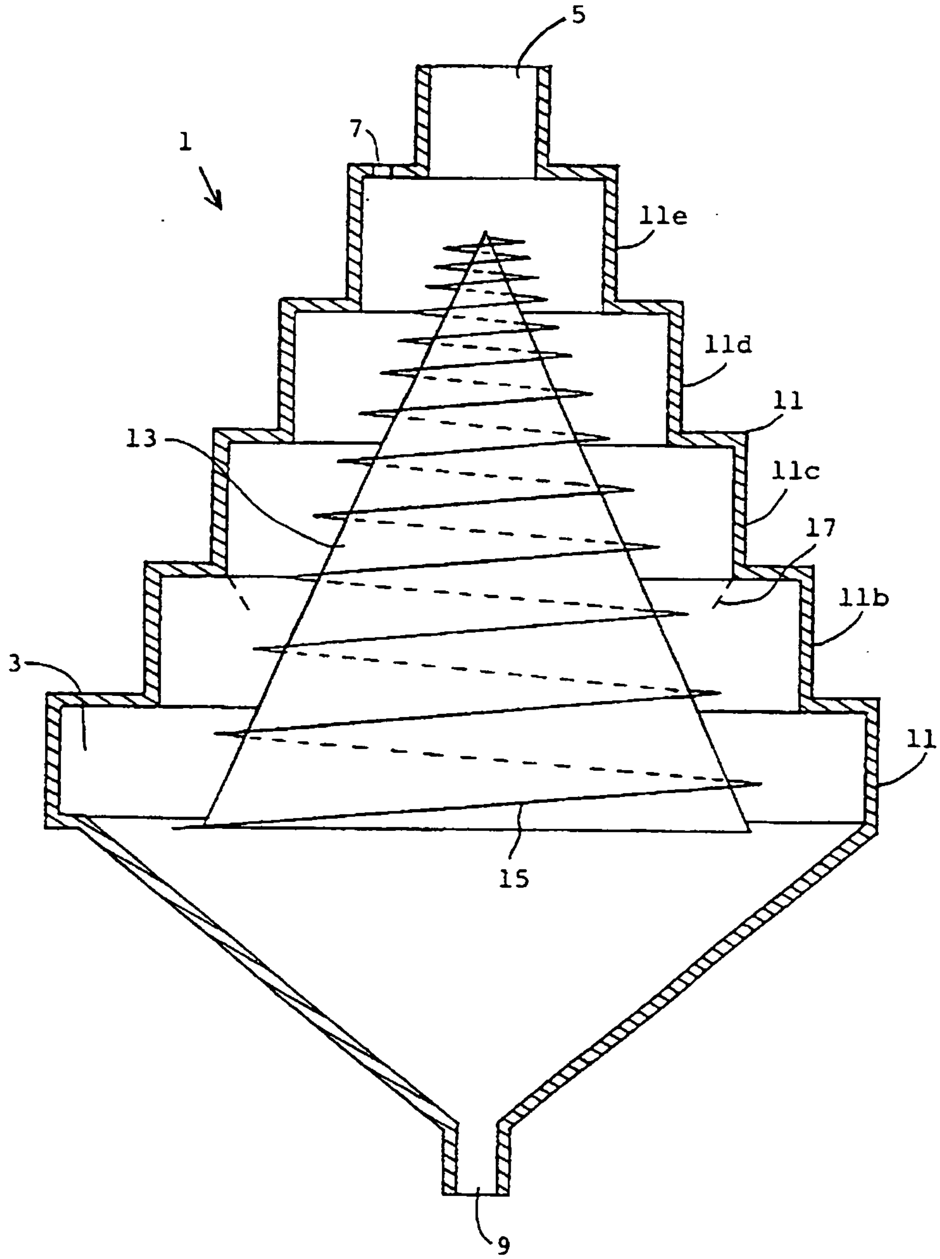
5. A device according to claim 4, **charact rized in that** the guiding means (15) consist of a helicoid guide plate with an angle of inclination of approximately 5°.

6. A device according to any one of the preceding claims, **characterized in that** the lower part of each shaft section is configured as an inverted truncated cone (17).

7. A device according to any one of the preceding claims, **characterized in that** the lower part of each shaft section protrudes slightly into the underlying shaft section.

8. A device according to any one of the preceding claims, **characterized in that** the relationship between the diameter and height of each shaft section is between 2 and 10, preferably between 3 and 6.

9. A device according to any one of the preceding claims, **characterized in that** the relationship between the diameters of two adjacent shaft sections is between 8:7 and 3:2, preferably between 6:5 and 4:3.


5
7
1
11e
11d
11
13
11c
17
11b
3
11a
15
9